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# ERCOT Large Load Modeling Requirements and Model Quality Test

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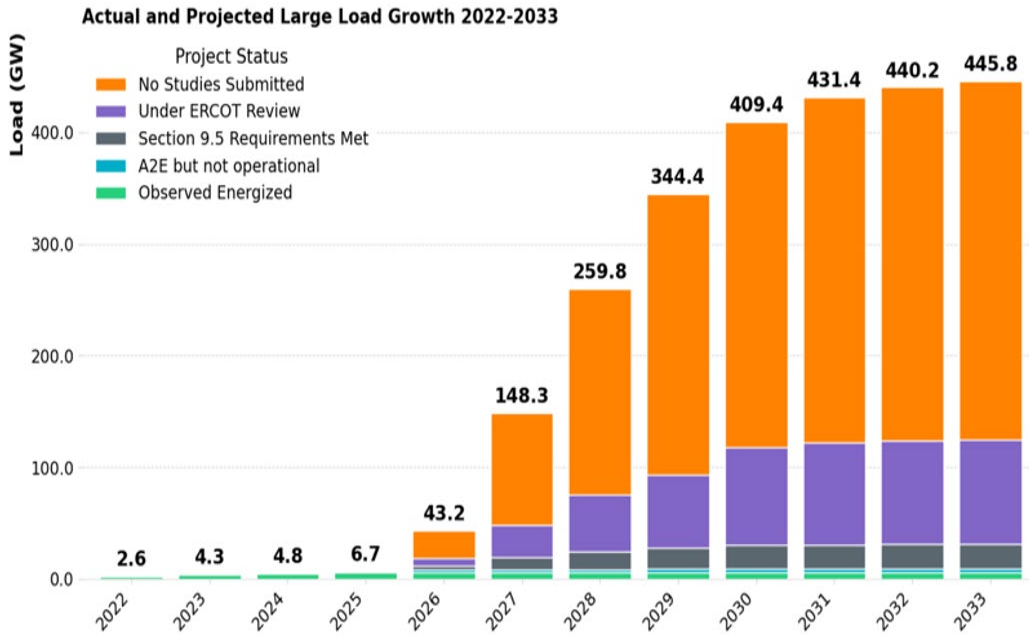
Public

# Challenges in Large Load Interconnection

- Approximately 400+ GW of Large Load, seeking interconnection
- Types: crypto mining, data centers, hydrogen production
- Some individual load > 1 GW
- Potential reliability risk (e.g., frequency or voltage instability)




- Source: 04-29-2026 Technical Advisory Committee (TAC) Meeting

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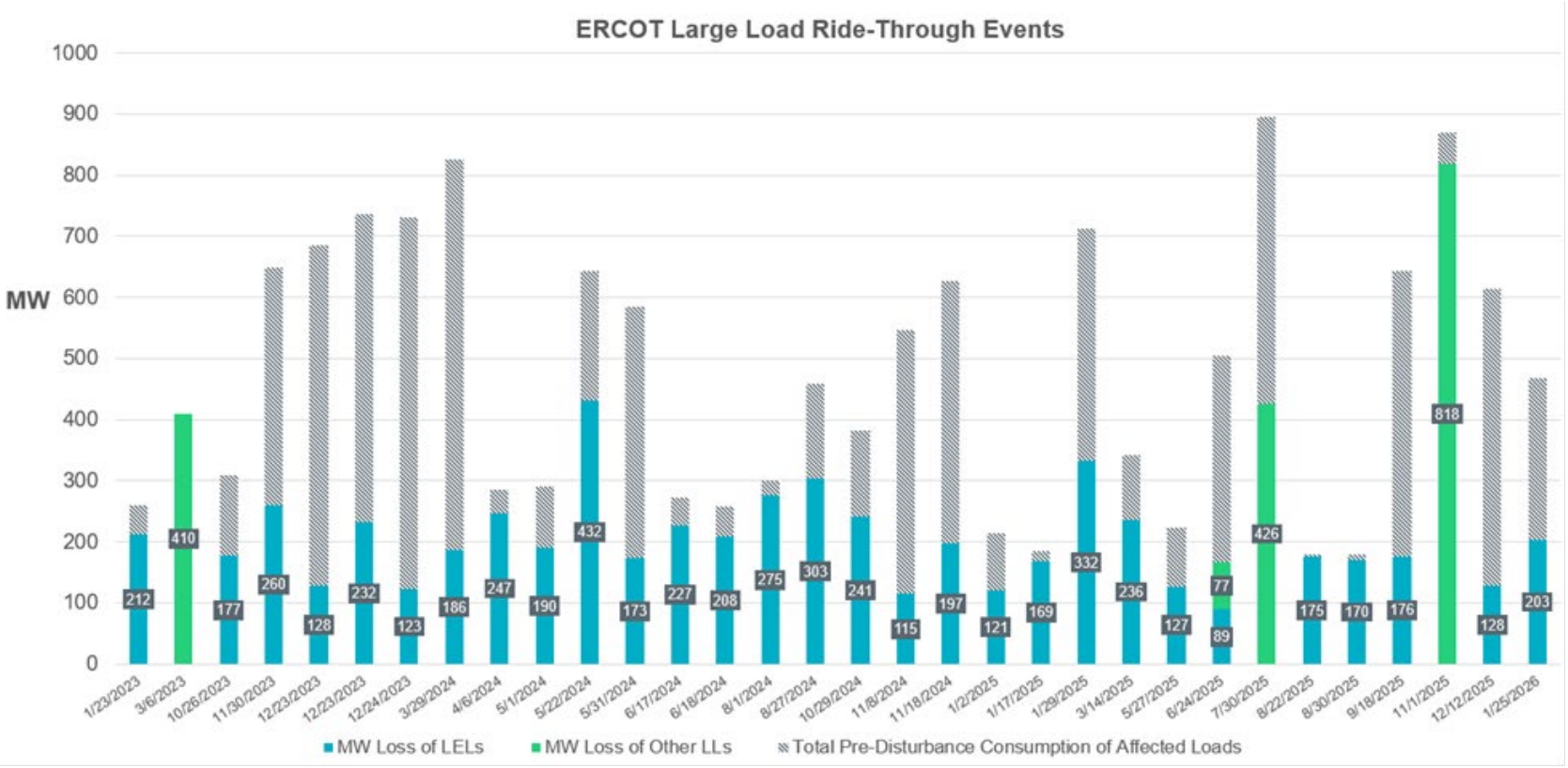
# Challenges in Large Load Interconnection




**Main Reliability Concern:**
ERCOT continues to see Large Computational Loads (LCLs) that are not riding through relatively common grid disturbances. As the number and size of affected load continues to grow, the risk of a major event increases.

Grid disturbance → Load trip or reduction → Potential reliability issue (e.g., frequency/ voltage stress)

# Modeling Gap and ERCOT's Interim Modeling Approach

- Why Accurate Models Matter
  - Enable reliable system assessments and reduce unnecessary sensitivity studies
  - Depend on accurate load data from customers
  - Data gaps and unclear requirements remain a challenge
- Current Model Limitations
  - Composite load model (CMLD) does not capture Large Computational Loads (e.g., data centers)
  - No standard model for Large Computational Loads (LCL)
- Until standard library models fully represent emerging data center and computational loads, the practical approach is to split the load into modeled components

- ERCOT accepts UDM or generic models as long as it can properly represents the facility's performance. User-defined Model (UDM) Is the Most Mature Option Today.
  - Adequate for representing the power-electronic portion of LCL
  - The UDM and associated documentation are available on the NERC LMWG website (link: https://dev.azure.com/nerc/_git/LMWG_Resources?path=/Data_Center_Model_PERC1)
- Interim temporary LCL Modeling Approach (if standard model is insufficient):
  - Split one LCL into two components:
    - Cooling portion→ model with CMLD (or UDM if applicable)
    - Power-electronic load (PEL) → model with UDM
  - Example: 30% cooling / 70% PEL, Split Load ID 1 → L1 (cooling) + L2 (PEL)
    - Model L1 with CMLD (or UDM), L2 with UDM
- Large Load Data Survey
  - ERCOT Dynamics Working Group Large Load Data Survey
- Path Forward
  - Transitioning from PSS/E v35 → v36
  - New standard models or UDM to represent emerging load types
  - Improved accuracy for future system studies

# Two Complementary Efforts in Progress: 1) Operating Requirements and 2) Model Review Process and Data Requirements

**NOGRR282: LCL Performance requirement in operations**

Defines voltage and frequency ride-through performances and related operating expectations for LCLs, including recovery, current limits, and low or high voltage response.

**PGRR144: Dynamic data requirements, submission, and model review process**

Clarifies dynamic data submission requirements and model review process for all Large Loads

# NOGRR282 (subject to change, under stakeholder review): LCL Ride-Through Requirements

- NOGRR282 creates a clear ride-through performance requirements for LCL

| Root-Mean-Square Voltage (p.u. of nominal) | Minimum Ride-Through Time (seconds) |
|---|---|
| **V > 1.20** | May ride-through or trip |
| **1.10 < V ≤ 1.20** | 1.0 |
| **0.90 ≤ V ≤ 1.10** | Continuous |
| **0.80 ≤ V < 0.90** | 2.0 |
| **0.50 ≤ V < 0.80** | 0.5 |
| **0.35 ≤ V < 0.50** | 0.25 |
| **V < 0.35** | 0.15 |

## Some Key Performance Indicators

**Voltage ride through performance**:
- Must remain connected and ride through specified voltage disturbances

**Active Power Performance**
- Maintain pre-disturbance load within normal voltage range
- Allow proportional reduction during low voltage events
- Restore ≥90% load within 2 sec after recovery (>0.9 p.u.)
- Maintain pre-disturbance load for 1.10–1.20 p.u. (up to 1 second)

**Low Voltage Response**
- Controlled load reduction allowed; proportional behavior expected where capable

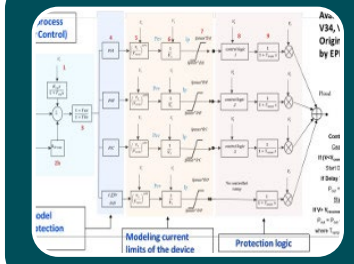
**Fast Recovery / Load Transfer Capability**
- Optional load-transfer schemes must initiate within 0.25 seconds
- Must restore ≥90% load within 0.5 seconds after voltage recovery

**Current Limits During Disturbance**
- Maximum current ≤150% of normal operation
- Duration limited to 0.5 seconds

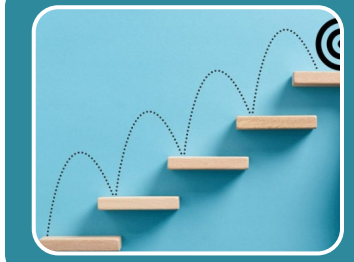
**Operational Flexibility**
- Cooling/mechanical load may trip at very low voltage (<0.35 p.u.)

# PGRR144 Dynamic Model Submission and Review Requirements for Large Loads including Large Computational Loads

- PGRR144 is currently under stakeholder review. Its key purpose is as follows:




Clarifies dynamic data requirements and require model quality test



Clarifies LL dynamic model data submission milestones for review

Clarifies process for potential material changes to the existing LCLs

# Dynamic Model Data Submission Requirements (PGRR144)

## Dynamic Model Data Submission Requirements

- Submission of dynamic data representing accurate behavior of LL should include models, parameters, and supporting documentation
- Software requirements: PSCAD required for all LLs
  - Data must be compatible with current ERCOT planning & operations software as described in DWG Procedure Manual Section 3.1.1, Software
- Model Quality Test is required for all LLs


Large scale, phase-domain analysis tool (e.g., Interconnection studies)


Electromagnetic Transient (EMT) tool for more detailed study (e.g., SSO study, Study for weak grid)


Operation software for real time TSAT analysis

# Model Quality Test Framework (PGRR144)

**Site-specific Model Quality Test (MQT) (All LLs)**

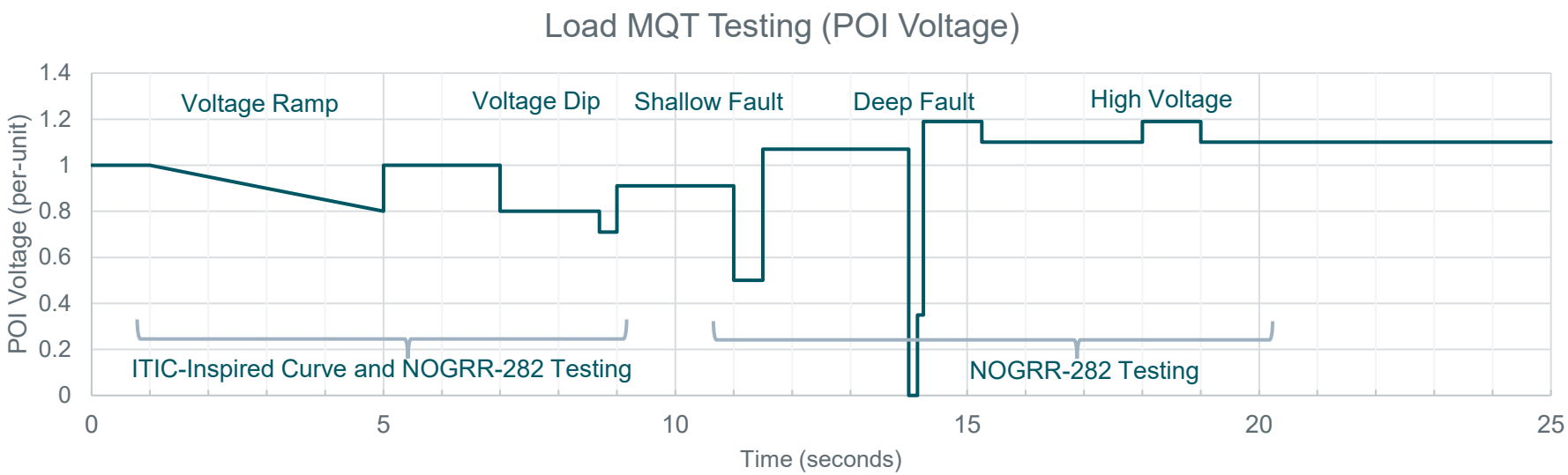
- Flat Start Test: Verifies proper model initialization and stable response under no disturbance
- Large Voltage Disturbance (VRT) Test: modeled voltage ride-through capability at the POI under large disturbances
- Demonstrate dynamic model meets the performance requirements
- The MQT must be performed using PSS/E, PSCAD, and TSAT (if PSS/E UDM is used)

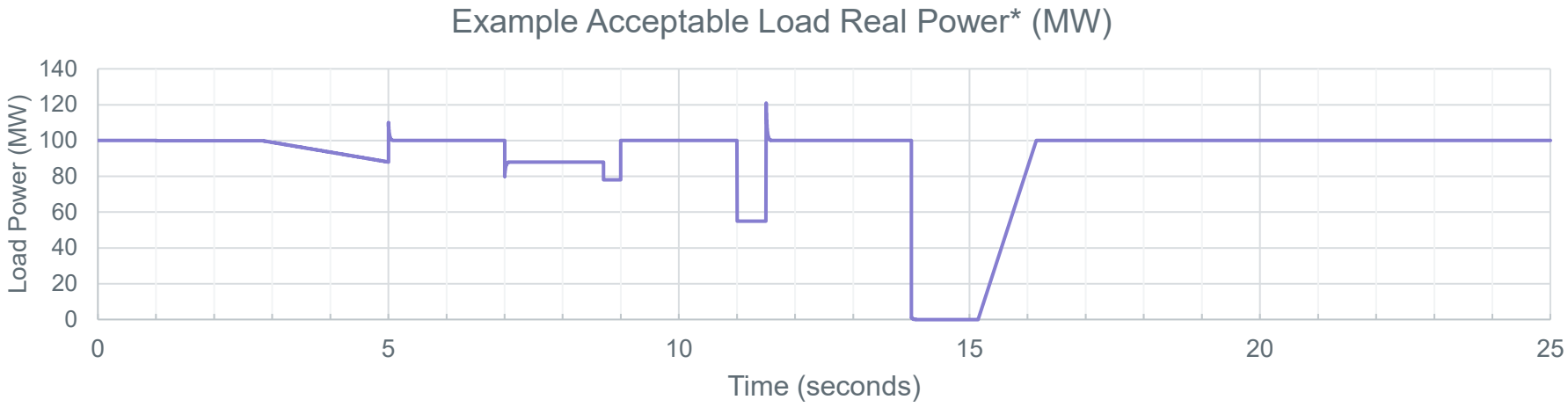
**Converter Model Validation Test (CMV) (LCLs only)**

- Hardware-type validation for the UPS converter and associated computational load
- Demonstrate accuracy of the PSCAD model of the converter type
- Large Voltage Disturbance (VRT) Test
- Subsynchronous Test (frequency scan sweep)

- MQT requirement for LCL vs Non-LCL
  - For LCL facilities, MQTs are required to demonstrate that the model of the project meets the ride through requirements (e.g., proposed VRT requirements in NOGRR282)
  - For non-LCL facilities, MQTs are required, with the purpose of improving understanding of voltage ride-through capability

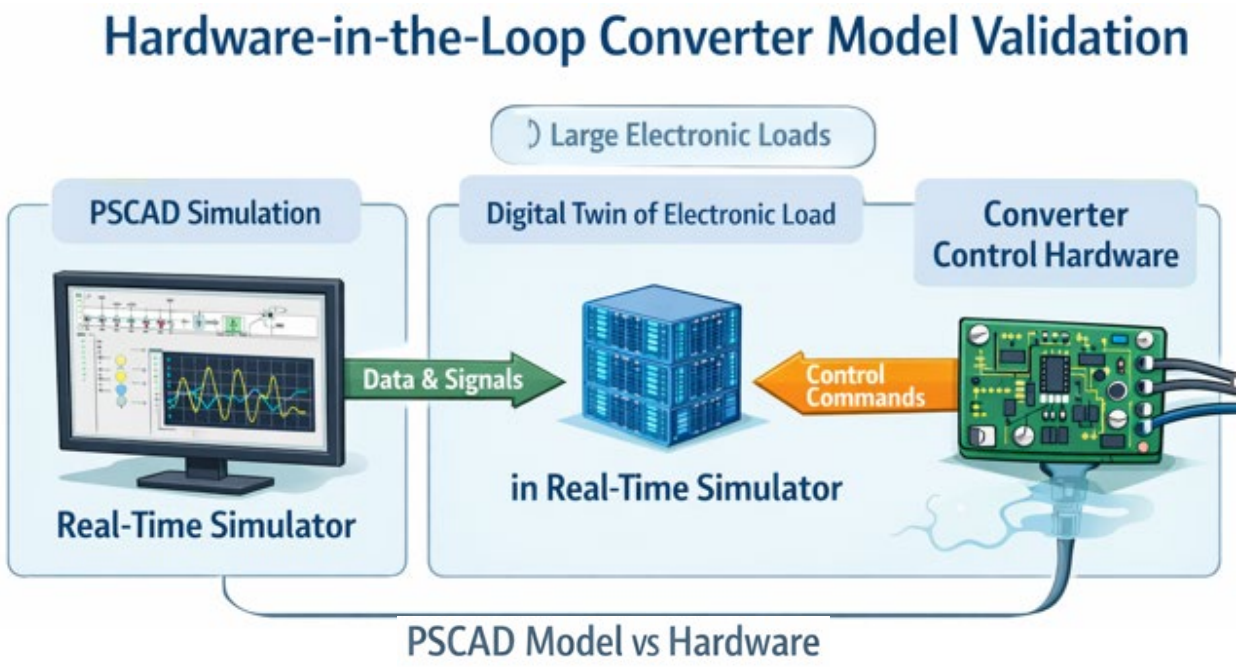
# Large Load Voltage Ride-Through (VRT) Test Curve




*** Note: This is an example of acceptable response**

# Converter Model Validation (CMV) Test for LCL




- Hardware-in-the-loop (HIL) testing is acceptable approach for this purpose. In practice, they connect the actual control hardware to a real-time simulator that represents the rest of the power system. The PSCAD model is then validated by comparing its simulated response to the measured behavior of the real equipment.
- Generally performed in OEM's laboratory. Usually performed once for a certain model or family of converters

# Key Milestones for Dynamic Model Review in the Interconnection Process (PGRR144)

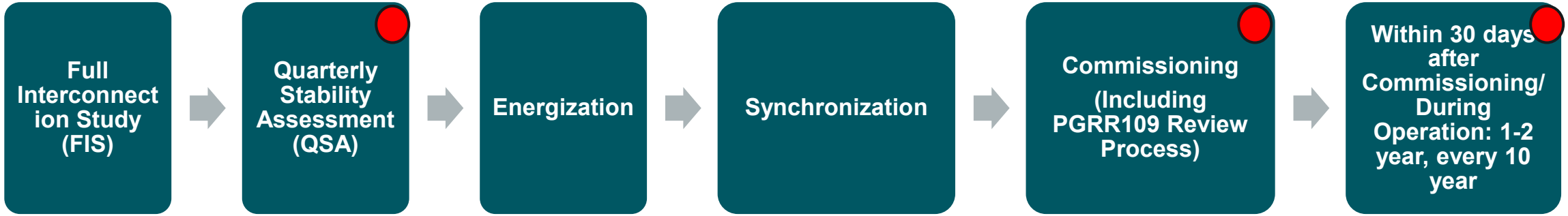
**Stability Study in LLIS** → **LL Quarterly Stability Assessment (QSA)** → **Initial Energization**

- **Before initiating stability study (Applicable to all LLs)**
  - Review submitted MQT, particularly VRT performance
- **Prior to entering QSA (Applicable to all LLs)**
  - This is in the current process
  - Test model performance
  - Check consistency against the data used in the stability study and consistency of performance across different software platforms (e.g., PSSE vs PSCAD)
- **Prior to initial energization (Applicable to LCL only)**
  - Check consistency between as-studied (QSA) data vs as-built data
  - Attestation that as-built data aligns with actual field settings

- **Note**: Completion of MQTs does not constitute an endorsement or a determination that an LCL will comply with the operating requirements established under NOGRR282 during operations.

# Co-located Large Load with New or Existing Resources - Existing Model Review Process

## Interconnection Process for New Resource or Major Modification




## Process for Existing IBRs with Planned Small Changes


: Key major milestones requiring model quality test and review
More details are available in Planning Guide Section 5

# Key Takeaways

- ERCOT, in collaboration with stakeholders, is developing requirements for Large Loads
  - NOGRR 282: Large Computation Load Ride-Through Requirements in Operations
  - PGRR 144: Dynamic Model Submission & Review Requirements
- The review process helps ensure consistency in model data and performance characteristics throughout the interconnection process.
- Ongoing industry engagement is critical to enhancing modeling approaches and reliability frameworks

# Questions?

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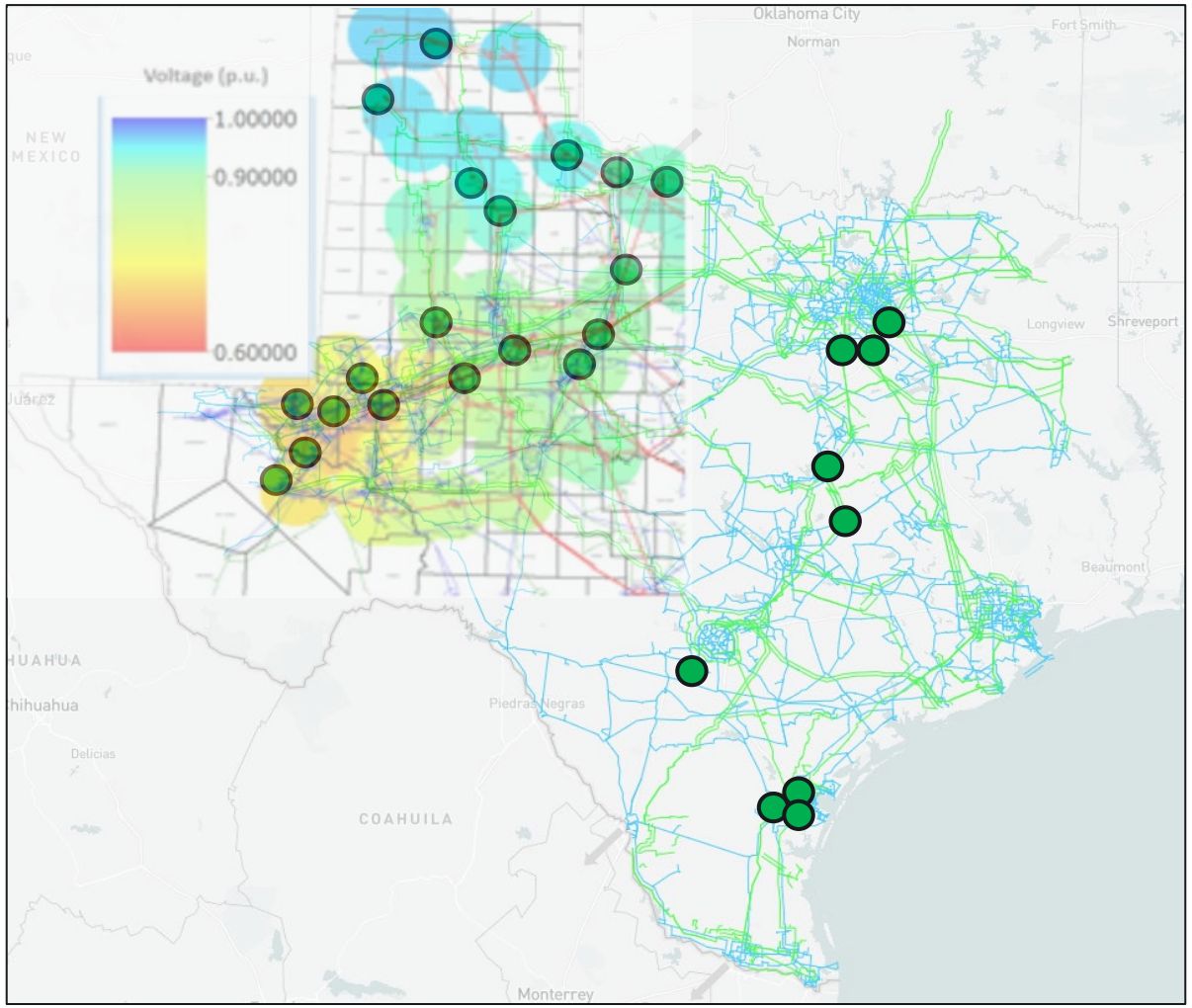
# Appendix - Example: Voltage Dips Under Certain Faults

**Note**: The voltage dip contour shown is a hypothetical illustration of potential wide-area voltage dips affecting Large Computational Loads. It does not represent actual system conditions.



# Appendix - Dynamic Model Data Submission Requirements (PGRR144)

| Software Platform | Current Process | Any Changes due to Proposed Requirements? |
|---|---|---|
| **PSS/E** | Required for all LLs | No change |
| **PSCAD** | Required for subsynchronous oscillation study (SSO) or co-located LLs | Required for all LLs |
| **TSAT** | Required for all LLs if PSSE User Defined Model (UDM) is submitted | No change |
| **Model Quality Test** using the software platform (i.e., PSS/E, PSCAD, and TSAT) | Required for RE/IE with co-located LLs, aiming to ensure resource ride-through performance | Required for all LLs |